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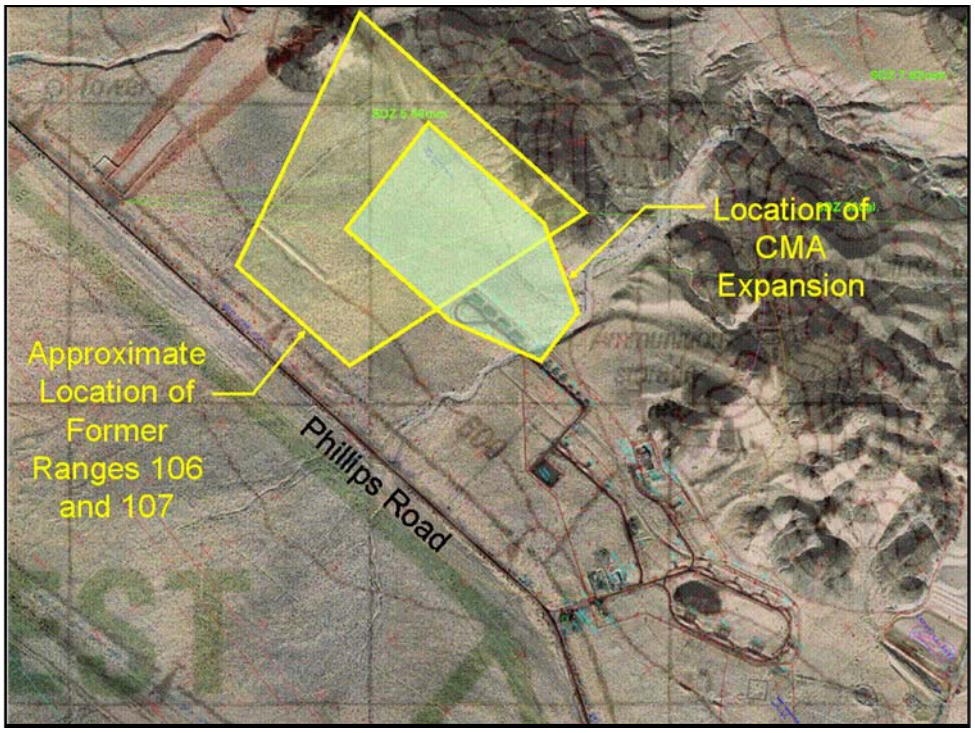
PRELIMINARY ASSESSMENT AT CENTRAL MAGAZINE AREA (CMA), FORMER RANGES 106 AND 107 MCAGCC TWENTYNINE PALMS, CALIFORNIA



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Twentynine Palms, California

Prepared by

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CAX	Combined Arms Exercises
CDFG	California Department of Fish and Game
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMA	Central Magazine Area
CNO	Chief of Naval Operations
CSM	conceptual site model
DNB	dinitrobenzene
DNT	dinitrotoluene
DoD	(United States) Department of Defense
DON	(United States) Department of Navy
DTSC	(California) Department of Toxic Substances Control
ECC	Environmental Chemical Corporation
EOD	Explosives Ordnance Disposal
ESQD	Explosive Safety Quantity Distance
ESA	Endangered Species Act
ESS	Explosives Safety Submission
HE	high explosives
HMX	high-melting explosive
JEG	Jacobs Engineering Group, Inc.
MCAGCC	Marine Corps Air Ground Combat Center
MILCON	military construction
MMRP	Military Munitions Response Program
NA	not analyzed
N/A	not available
ND	not detected
OE	ordnance and explosives
PA	Preliminary Assessment
PD	point-detonating fuses
PMI	pearlitic malleable iron
Q-D	quantity-distance
RDX	Research Department Explosive (hexahydro-1,3,5-trinitro-s-triazine)
RTA	Range Training Area
SARTS	Small Arms Remote Target System
TDS	total dissolved solids
TNT	trinitrotoluene

U.S. EPA	United States Environmental Protection Agency
U.S. NEODTD	United States Naval Explosives Ordnance Disposal Technology Division
USFWS	United States Fish and Wildlife Service
UXO	unexploded ordnance
WP	white phosphorus

Section 1.0: INTRODUCTION

The current volume of stored munitions and its proximity to a public traffic route has led to a condition where the Central Magazine Area (CMA) at Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, CA, is no longer in compliance with Explosive Safety Quantity Distance (ESQD) regulations (Department of Navy [DON], 2002). This situation will be complicated further by the projected 50% increase in munitions support requirements for future training activities at MCAGCC. A temporary waiver from the Chief of Naval Operations (CNO) was issued to continue maximum-capacity operations, with the stipulation that activities be commenced to plan and construct additional storage capacity. Per this directive, MCAGCC has evaluated options to expand and redistribute storage at their CMA by constructing five additional storage bunkers, a new battery charging station, and two additional hardstand ammunition breakdown pads. The CMA expansion is being conducted as the military construction (MILCON) Project P-683.

One of the two proposed hardstand construction projects (south project site) is directly adjacent to the CMA and will use existing CMA property. This land use is consistent with its current status. The remaining proposed CMA expansion involves the use of approximately 30 acres of land previously associated with range training, designated as former Range 106 and former Range 107. Although training activities ceased at these ranges c. 1985, they were never declassified from their "active/inactive" status to "closed."

The United States Department of Defense (DoD) and the Navy are currently establishing policy and guidance for munitions response actions under the Military Munitions Response Program (MMRP). Key program drivers developed to date conclude that munitions response actions will be conducted in a manner consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Therefore, a Preliminary Assessment (PA) was performed for Former Ranges 106 and 107 at MCAGCC.

The purpose of this assessment is to review information to determine the need for further action at the CMA to ensure the protection of human health and the environment. The scope of this assessment included a review of existing information about the site, including previous environmental reports prepared for MCAGCC, an initial evaluation of risks associated with potential unexploded ordnance (UXO), and the potential impact of munitions-related chemical constituents at former Ranges 106 and 107. Although this PA generally follows CERCLA guidance, certain elements of the report have been tailored to address the unique explosives safety aspects of munitions and explosives.

This PA has the following sections:

A compact disk is included with this PA which contains an electronic copy of this document, its appendix, and source documents.

Section 2.0: SITE BACKGROUND

2.1 Site Location

MCAGCC Twentynine Palms is an active military installation located in south-central San Bernardino County, CA (Figure 2-1). The Base covers approximately 935 square miles of remote desert and is used primarily for live-fire training exercises. The southern boundary of the installation is adjacent to the City of Twentynine Palms and is approximately 6 miles (10 km) north of Highway 62. The northern boundary is located south of Interstate 40. Other communities within the vicinity of MCAGCC include Joshua Tree, Yucca Valley, and Landers. MCAGCC training mission dictates the use of large quantities of munitions. The primary storage facility for energetic materiel is the CMA. The CMA is located at the southern portion of the installation, in the Range Training Area (RTA) northwest of the Mainside area (Figure 2-2).

2.2 Type of Facility and Operational Status

The U.S. Army began using the Base, then called Camp Condor, in 1941 to train glider crews and by 1943 the area was used extensively for fighter pilot training. The U.S. Navy also used the Base for bombing and gunnery ranges until the end of World War II. At the end of the World War II, Camp Condor became inactive until the U.S. Marine Corps reactivated the facility in 1952. The MCAGCC was established to provide the Marine Corps with a training facility that would permit military exercises with

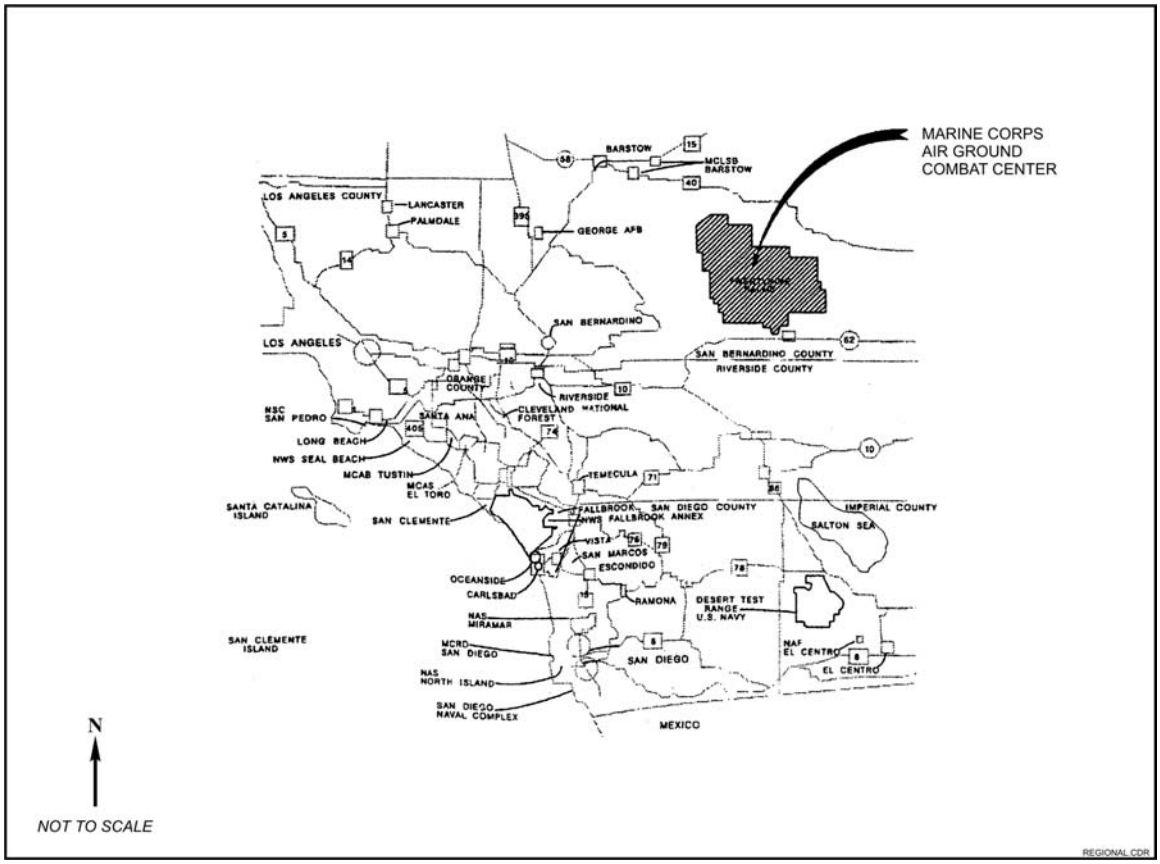

Figure 2-1. Marine Corps Air Ground Combat Center Twentynine Palms, CA

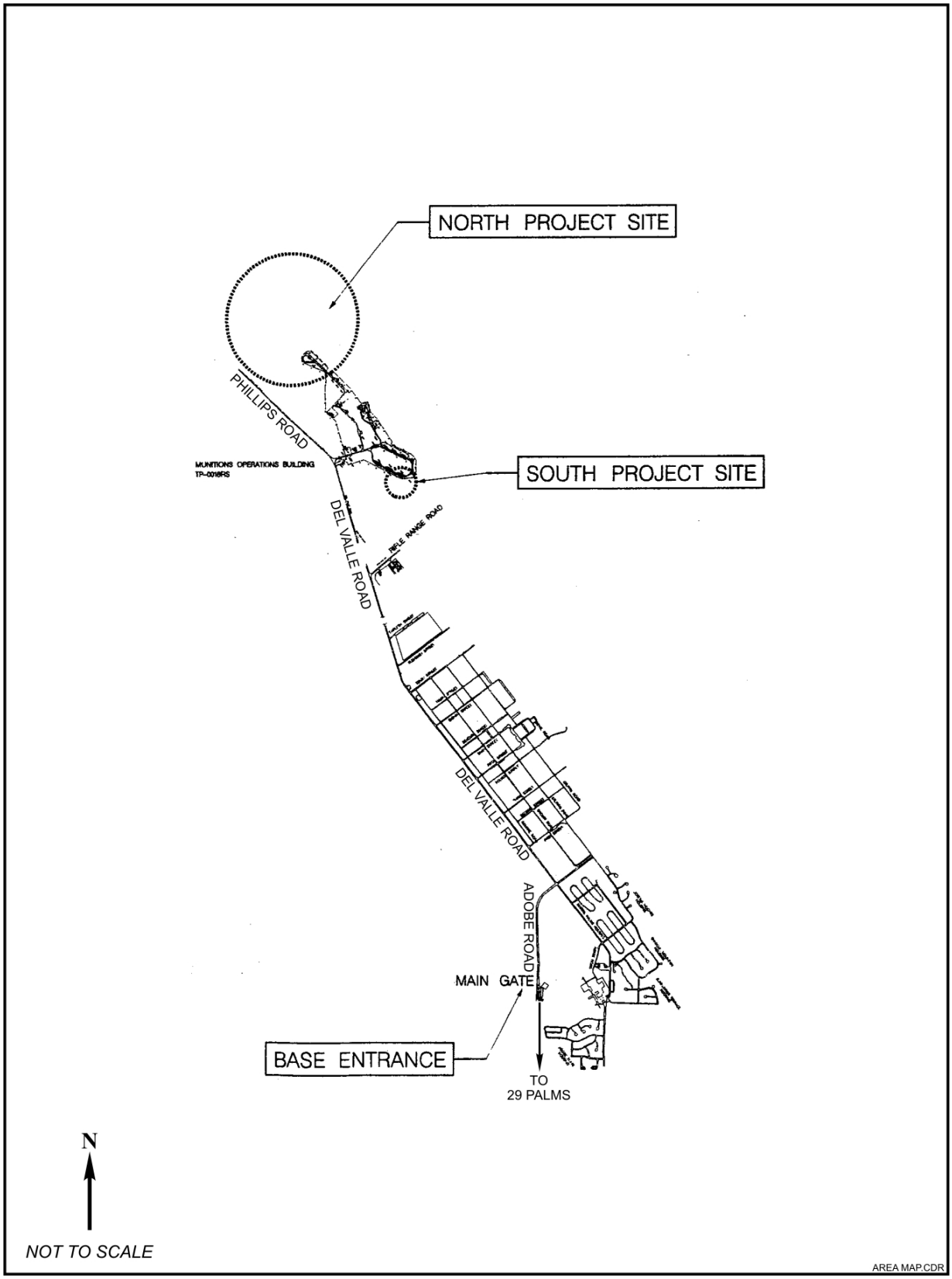

Figure 2-2. Location of CMA in Reference to MCAGCC Mainside

weaponry that could not be used at existing bases such as Camp Pendleton. The Marine Corps presently uses the facility for basic training and also to perform Combined Arms Exercises (CAX), in which large-scale maneuvers by U.S. and Allied Forces carry out live-fire exercises in the high desert conditions.

The CMA has undergone several construction phases (1955, 1961, and 1986) to accommodate the need for increased munitions capacity to support larger and more complex CAX. Storage capacity of the CMA has been maximized to meet the current CAX requirements and stands at approximately 4.3 million pounds. The expansion of the facility will increase storage capacity to approximately 6.3 million pounds, which is the projected need for multiple, large-scale military exercises. This mandated expansion requires the use of land from the former Ranges 106 and 107 (Figure 2-3).

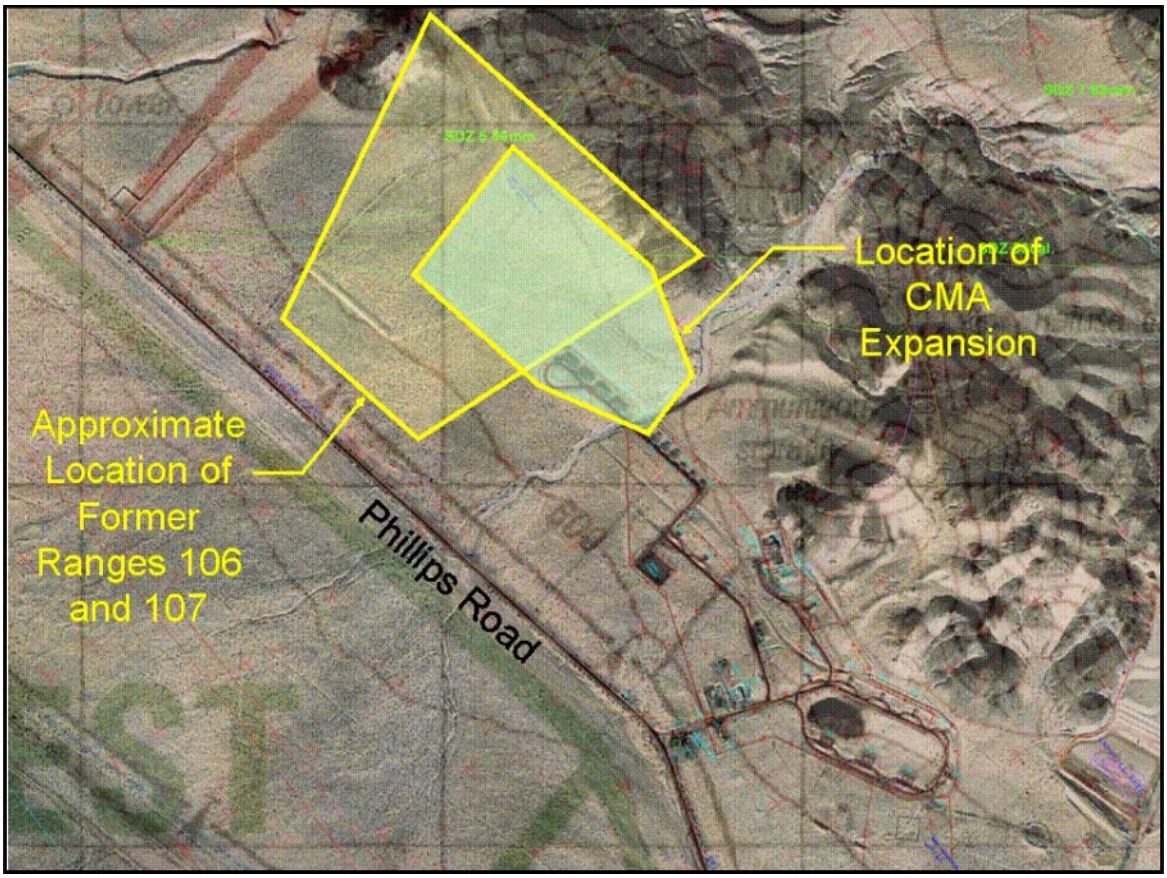

Figure 2-3. Location of CMA Expansion and Former Ranges 106 and 107

2.3 Structures and Topography

The CMA and former Ranges 106 and 107 at MCAGCC Twentynine Palms are located on the eastern edge of the Morongo Basin. This large tectonic basin is within the southeast portion of the Mojave Desert Geomorphic Province. The basin is generally defined by moderately rolling desert topography and is characterized by a series of northwest-trending normal and strike-slip faults. The blocks between the faults form individual groundwater sub-basins that are partially connected hydraulically across low-permeability materials adjacent to the fault zones. These northwest-trending geologic features are sub-regional in extent, and the West Bullion Mountain fault defines the eastern limit of the regional groundwater basin.

The RTA is situated on the gentle slope of a southwest-trending alluvial fan. This fan extends from the Bullion Mountains to the northeast to the edge of Mesquite Lake to the south. The topography has been only slightly modified by cutting the upper portion of the slope and filling the lower portion adjacent to the dry lake. Mesquite Lake is a flat-lying dry lake adjacent to the Mesquite Lake fault and occupies the southwestern edge of MCAGCC. This area is largely unused, except for several earthen-bermed sewage evaporation ponds.

An intermittent drainage arroyo runs through the CMA and another arroyo is located approximately 50 ft to the south of the CMA. Runoff from the CMA and RTA flows southwest towards Mesquite Lake (DON, 2002). Mesquite Lake is dry throughout most of the year, but seasonal precipitation and runoff from surrounding watersheds occasionally recharge this low lying area. Mesquite Lake has an impermeable natural soil cap which prevents any significant percolation of surface water flow (Law and Crandall, 1996). The primary method of surface water loss is through evaporation.

2.4 Geology and Hydrogeology Information

The MCAGCC is located in the Morongo Basin which is characterized by unconsolidated deposits of eolian sand, alluvial sands and gravels, and lacustrine silts, clays, and evaporates in playa lakes. The near-surface deposits are underlain by older alluvial sand deposits with minor gravel layering. Bedrock in the basin near MCAGCC is 1,000 to 3,000 ft below ground surface (bgs) and is composed of crystalline igneous and metamorphic rocks. The RTA is located on Cajon soils (Jacobs Engineering Group, Inc. [JEG], 1995) derived from alluvial fan materials and are primarily composed of a light brownish-gray fine sand. These soils are well drained and have moderate to high permeability. The Cajon soils are located in a zone corresponding to the occurrence of the alluvial fan and lie between the adjacent lacustrian soils of the playa lake (i.e., Mesquite Lake) and the outcropping quartz monzonite bedrock of the Bullion Mountains. The Bullion Mountains are the parent material of the alluvial fan/Cajon soils.

Environmental investigations in the Mainside Area have encountered fine to medium alluvial fan deposits with sand and some angular cobbles and gravel fragments. Occasional thin gravel lenses or clayey silt and sand lenses also have been encountered during environmental drilling operations. These alluvial deposits are interlaced with lacustrine clays that are the predominant lithology near the bottom, or downslope area, of the Mainside Area of MCAGCC.

Groundwater in the Morongo Basin occurs within unconsolidated continental sedimentary deposits (i.e., gravel, sand, silt, and clay) of Quaternary and Tertiary Ages that reach a maximum depth of approximately 10,000 ft near Deadman Lake on MCAGCC (Mendez and Christensen, 1997). These water-bearing materials are underlain and surrounded by Mesozoic-age igneous rocks that generally are not water-bearing except in fractures and joints where porosity is available.

The primary water table beneath the RTA is referred to as the Mesquite Lake sub-basin. Water level in this aquifer occurs at approximately 140 ft bgs (Law and Crandall, 1996). Water quality data for the Mesquite Lake sub-basin is poor due to high concentrations of fluoride and various other minerals that exceed United States Environmental Protection Agency (U.S. EPA) standards. The groundwater also has total dissolved solids (TDS) levels above maximum contaminant levels (MCLs) (State of California, 2002). Two groundwater wells were completed in the Mesquite Lake sub-basin for irrigation purposes, but because of the elevated TDS levels, neither well is operational (Law and Crandall, 1996).

Groundwater monitoring wells exist approximately 0.5 miles east of the CMA and are associated with Base Landfill No.2. Between 1987 and 1995 twelve groundwater monitoring wells were

drilled to depths ranging from 50 to 347.5 ft bgs and in all cases no groundwater was encountered (Woodward-Clyde, 1995). Based upon these well depths without encountering groundwater, the Regional Water Quality Control Board approved suspending requirements for groundwater monitoring at Landfill No.2. In July 2000, an Order to MCAGCC from the Regional Board stated that the average depth-to-groundwater downgradient of the landfill was 404 ft bgs (California RWQCB, 2000).

2.5 Surrounding Land Use and Populations

The population of MCAGCC is quite variable, but generally stands at approximately 10,000 military personnel. The 2000 U.S. Census reported the population of the City of Twentynine Palms to be 14,764.

Former Ranges 106 and 107 are approximately 3 miles from the Mainside Area of the MCAGCC, which is located 6 miles north of the city of Twentynine Palms, CA, and is separated from the developed area of the nearby community by approximately 2 miles of sparsely populated desert.

2.6 Endangered and Special Status Species

As summarized in the Final Environmental Assessment for the Proposed Ammunition Storage Facilities (DON, 2002), special-status species are defined as those plant and animal species listed as threatened, endangered, or proposed as such by the U.S. Federal Fish and Wildlife Service (USFWS) or California Department of Fish and Game (CDFG). The federal Endangered Species Act (ESA) protects federally listed threatened and endangered plant and animal species. The State of California, under the California ESA, uses a classification system similar to the federal ESA for protected species.

Although 26 special status species (11 plants, 1 lizard, 9 birds, and 5 mammals) are known to occur on MCAGCC, none is known to occur or have the potential to occur within the area associated with the CMA expansion, primarily due to the lack of suitable habitat.

One federally and state-listed threatened species, the desert tortoise (*Gopherus agassizi*), is known to occur in the mountains adjacent to the CMA. Desert tortoise surveys were conducted near the CMA in January and February 2002 and desert tortoise, desert tortoise burrows, and suitable desert tortoise habitat were not observed.

2.7 Climate

The Morongo Basin area of the Mojave Desert is classified as having an arid, upland desert climate. The summer months are characterized by high temperatures, low humidity, and clear, sunny days. The average annual temperature is 67°F. Temperatures frequently exceed 100°F, and occasionally reach 120°F in the summer, and drop to as low as 15°F in winter months. Average annual precipitation is about 4 inches, most of it a result of thunderstorms from July to January. The average annual evaporation rate is 120 inches. Some freezing rain and snow does occur during the winter at higher elevations. The relative humidity averages 29% and ranges from 2% in the summer to 60% in the winter. The prevailing wind is from the northwest, west, and southwest. The average wind velocities vary from 3 to 12 miles per hour, and can gust to more than 50 miles per hour.

Section 3.0: DATA COLLECTION SUMMARY

Five types of information were researched as part of the data collection effort for this PA. The types of data include:

1. Historical archive data in the form of military documents from off-site repositories.
2. Installation reports that relate to the proposed site activities.
3. On-site technical data from sampling and analysis.
4. Off-site technical research data.
5. Visual surveys.

Data used to develop this PA are summarized in Table 3-1. Copies of these data are provided in electronic format on the attached CD.

Table 3-1. Summary of the Primary Historical Data References

Reference	Summary
Range Identification and Preliminary Range Assessment, Final, Marine Corps Air Ground Combat Center, Twentynine Palms, CA. Prepared by US Army Corps of Engineers. September 2001.	Historical range summaries and preliminary range assessments, range training areas, general munitions safety issues.
Archives Search Report, Final, Marine Corps Air Ground Combat Center, Twentynine Palms, CA. Prepared by US Army Corps of Engineers. September 2001.	Historical summary of site description, site history, real estate, site inspection, range summary references, maps, photographs.
Final, Environmental Assessment. Proposed Ammunition Storage Facilities (P-683) at Marine Corps Air Ground Combat Center, Twentynine Palms, CA. September 2002.	Description of proposed action, affected environment, environmental consequences, other considerations associate with NEPA.
Final, Explosives Safety Submission Munitions Response Action MILCON Project P-683, Central Magazine Area, Marine Corps Air Ground Combat Center Twentynine Palms, CA. April 2003.	Reasons for UXO/OE, amounts and types of UXO/OE, clearance techniques, OE scrap explosive hazards, alternative techniques, technical support, land use restrictions, public involvement, maps, quantity distance.
Programmatic Environmental Assessment. Ongoing and Proposed Training Activities at Marine Corps Air Ground Combat Center, Twentynine Palms, CA. May 2003.	Establishes and compares environmental impacts associated with training efforts at current operational levels and at a 15% increase.
Map of the P-683 Storage Facility, 100% Design.	Proposed construction reference.
Closure Report, Characterization of Spent Shell Casings, Twentynine Palms, CA. Prepared by Environmental Chemical Corporation (ECC), D.O. No. 0014, March 1999.	Analytical data from munitions and range residue.
Closure Report, Characterization of Spent Shell Casings, Twentynine Palms, CA. Prepared by ECC, D.O. No. 0019, October 1999.	Analytical data from Range 112 range residue.
Sampling data from Quackenbush and Range 400.	Historical analytical data for range residue.
Standing Operating Procedures for Range/Training Areas and Airspace, Marine Corps Air Ground Combat Center, Twentynine Plams, CA. Combat Center Order P3500.4F, July 2000.	Current status of range operations at MCAGCC.

OE = ordnance and explosives.

3.1 Off-Site Historical Archive Repositories

Offsite archive sources that were reviewed and that provided information to complete this PA include:

- National Archives, Washington DC.
- National Personal Records Center
- Naval History Center Library
- Naval Aviation History Center
- Naval Historical Center (Photo Archive)
- National Imaging and Mapping Agency
- U.S. Air Force Historical Research Agency
- National Archives – Pacific Southwest Region
- Federal Records Center- Los Angeles
- U.S. Department of Interior-Bureau of Land Management
- California State Archives Library
- U.S. Geological Survey.

3.2 Installation Reports

Assets from the MCAGCC were also included in the archives search. Base information repositories included:

- Natural Resources and Environmental Affairs Directorate
- Installation and Logistics Directorate
- Operations and Training Directorate
- Base Library.

3.3 On-Site Technical Data

Reports associated with sampling and analysis of range soils, range residues, and the demolition of UXO were evaluated.

3.4 Off-Site Technical Research Data

A literature search was performed to identify any additional studies, relating to the occurrence and persistence of munitions related chemical constituents.

3.5 Visual Surveys

Visual surveys of Ranges 106 and 107 were performed during the development of the Explosive Safety Submission for MILCON P-683 (ECC, 2003), during Explosives Ordnance Disposal (EOD) survey activities, and during site walks by subcontractors associated with the development of this PA. These surveys confirmed the existence of munitions residues from previous training activities (i.e., shell casings, bullets, mortar fins assemblies, and other subcomponent fragments).

Section 4.0: OPERATIONAL HISTORY AND SITE CHARACTERISTICS

4.1 Operations at Former Ranges 106 and 107

Range 106 first appears on installation maps in 1974 as the Small Arms Remote Target System (SARTS) facility. The range was located northwest of the CMA storage area and had a firing line defined by grid coordinates 842928 to 844926. This SARTS facility included 20 small "pop-up" targets, with a maximum range of 1,000 meters.

Range 107 was identified in installation documents as a mortar range defined by grid coordinates 84099290 to 83839300 with a firing direction to the northeast. Range 107 allowed firing of 60-mm and 81-mm mortars with target ranges varying from 500 to of 3,500 meters.

Base records show that by 1988 training Range 106 and 107 activities had been moved 0.5 kilometer to the southwest, away from the area of interest for this PA (USACE, 2001). The appearance of these ranges on 1974 maps but not on 1988 maps implies that Ranges 106 and 107 were used for approximately 10 to 15 years. These dates also imply that no mortar training has occurred for more than 25 years at the ranges, although some small-arms firing may have taken place within the past 5 years (Sanderson, 2003)

Items listed and described in Table 4-1 were identified as allowable munitions in the Standing Operating Procedures for Range/Training Areas and Airspace (P3500.4A, 1984) for use on Ranges 106 and 107.

Historical records for Ranges 106 and 107 do not provide information on the estimated total numbers of munitions used on these ranges or the amount of munitions removed during periodic range-gleaning activities.

Table 4-1. Description of Munitions Used at Former Ranges 106 and 107 of MCAGCC

Description	Body Material	Weight	Energetic	Energetic Weight
60 mm HE, M49A3	Cast PMI	3.07 lb	Comp B, TNT	0.42 lb, 0.34 lb
60 mm Illum, M83	Steel Tubing	4.15 lb	Magnesium, sodium nitrate	0.49 lb
60 mm WP, M302	Forged Steel	3.98 lb	WP, Tetryl	0.75 lb, 0.38oz
81 mm HE, M43A1	Forged Steel	7.5 lb	Comp B	1.29 lb
81 mm HE, M56	Steel	15.01 lb	TNT	4.3 lb
81 mm HE, M362	Forged Steel	9.42 lb	Comp B	2.1 lb
81 mm HE, M374	Forged Steel	9.34 lb	Comp B	2.1 lb
81 mm WP, M57	Steel	11.38 lb	WP, Tetryl	4.06 lb, 0.08 lb
81 mm WP, M370	Steel	9.34 lb	WP, RDX	1.6 lb, 0.025 lb
81 mm Illum,M301	Steel Tube	10.7 lb	Magnesium, sodium nitrate	1.37 lb
5.56 mm Ball, M193	Brass	182 grains	Nitrocellulose, nitroglycerin	26.5 to 28.5 grains
7.62 mm Ball, M80	Brass	392 grains	Nitrocellulose, nitroglycerin	46 grains
.30 Caliber Match, M72	Brass	425 grains	Nitrocellulose, nitroglycerin	50 grains

(Information derived from Technical Data Sheets TM 43-0001-27 and TM 43-0001-28; see Appendix A).
HE = high explosive.
PMI = pearlitic malleable iron.
RDX = research department explosive.
TNT = trinitrotoluene.
WP = white phosphorus.

In April 2002, a MCAGCC EOD unit performed a surface reconnaissance. During that exercise, the following munitions listed in Table 4-2 were identified in the area of MILCON Project P-683. The items observed were in agreement with the allowable types of munitions for the former ranges (Table 4-1).

Table 4-2. UXO and Small-Arms Items Identified During the EOD Site Inspection

Type	Approximate Quantity
60 mm HE	3
60 mm WP	3
60 mm Illuminating	5
81 mm HE	7
81 mm WP	2
81 mm Illuminating	3
5.56 mm Ball	20
7.62 mm Ball	5
.30 caliber Ball	2

Source: ECC, 2003.

4.2 Munitions Evaluation

Historical records indicate two categories of munitions were used at Former Range 106 and 107: small-arms ammunition and mortars.

4.2.1 Small Arms Ammunition. Small-arms ammunition residues exist at former Range 106. During site walks, 5.56-mm ball, 7.62-mm ball, and .30 caliber Match were observed. This class of small-arms ammunition consists of four primary components: (1) case; (2) propellant; (3) primer; and (4) bullet (see Figure 4-1).

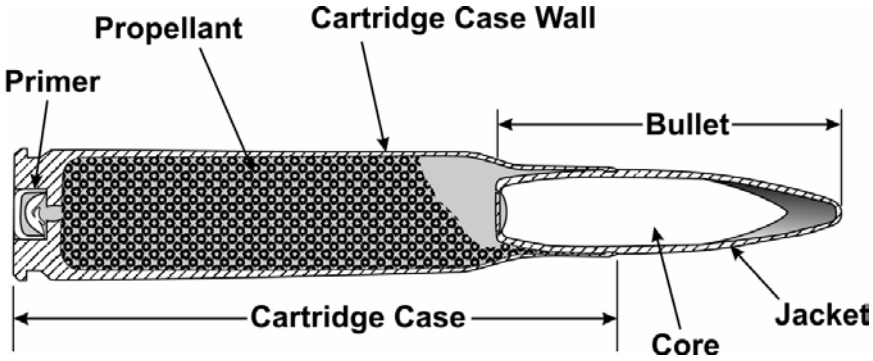

Figure 4-1. Typical Components of Small-Arms Ammunition

Case material for rifle or pistol rounds is most commonly brass, consisting of 70% copper and 30% zinc.

Propellants for small arms ammunition are either single-base (nitrocellulose) or double-base (nitrocellulose and nitroglycerin). Propellant type, grain shape, propellant weight, and the addition of deterrents contribute to the pressure required to safely accelerate the projectile (bullet) to the desired ballistic performance.

Primers in small-arms ammunition are one of two types: percussion or electric. Based on the cases observed during site walks, it appears that small-arms residues at Range 106 are predominantly percussion. A percussion primer consists of a metal cup that contains a pressure sensitive explosive materiel (typically, lead styphnate: legal label name for lead trinitroresorcinate) that is secured by a brass anvil. When the firing pin impacts the primer it compresses the energetic material between the cup and the anvil, causing it to detonate. Holes in the anvil allow the hot gases from the primer detonation to enter the case where the propellant resides, resulting in its ignition.

Bullet residues observed at Range 106 consist of either ball or match types. Ball ammunition is typically copper clad steel with a lead core and is intended for training and general purpose combat. Match ammunition is used in shooting competitions and the bullet consists of a gilding-metal jacket over a lead core.

Army Ammunition Data Sheets for Small Caliber Ammunition (FSC 1305) are provided in Appendix A (TM 43-0001-27, April 1994).

4.2.2 Mortars. Mortar residues exist at Range 107. During site walks, residue from 60-mm HE, 60-mm illumination, 60-mm WP, 81-mm HE, 81-mm WP, and 81-mm illumination rounds were observed. Mortars of these types are of similar construction and consist of six primary components: (1) fin assembly; (2) primer; (3) ignition cartridge; (4) propellant charge; (5) projectile body containing explosives, smokes, or illuminants; and (6) the fuse (see Figure 4-2).

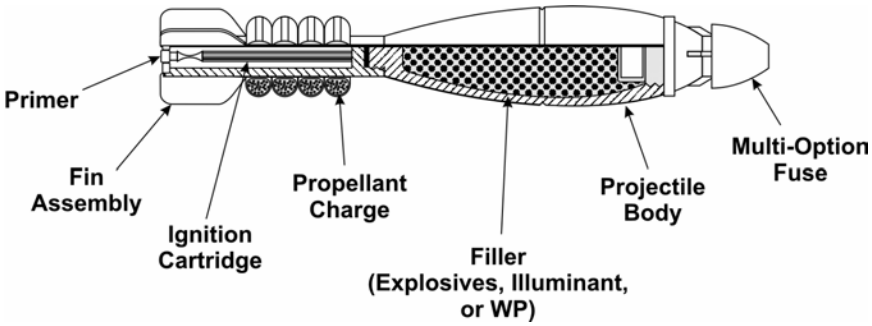

Figure 4-2. Typical Components of a Mortar Round

Fin assemblies are typically fabricated from aluminum or steel and are intended to stabilize the mortar while in flight. Entire fin assemblies would remain as residue from illuminant mortars. High explosive, and WP spotting charge mortars undergo an explosive episode that typically fragments the fin assembly.

The primer is located in the base of the fin assembly and is either percussion or electrically triggered. The 60- and 81-mm mortars at former Range 107 are primarily of the vintage where percussion primers were employed. Primers typically contain a mixture of pressure-sensitive materials such as lead thiocyanate (25%), potassium chlorate (53%) antimony sulfide (17%), and TNT (5%). When fired, the mortar is dropped into a launching tube that contains a firing pin at its base. The weight of the mortar falling onto this pin compresses the primer material and causes its detonation.

An ignition cartridge is required, in addition to the primer, to provide the necessary volume of hot gases to efficiently ignite the relatively large volume of propellant associated with a mortar round.

The ignition cartridge contains single- or double-base propellants and is located inside the fin assembly, ahead of the primer.

Propellant charges are positioned either between the fins or on the tubular portion of the fin assembly below the projectile body. Propellant charge composition can vary but typically consists of single- or double-based propellants with accelerators or deterrents. When ignited, the expanding gases from the propellant charge drives the mortar from its launching tube. The number and size of the propellant packages dictate the ballistic path of the projectile.

The projectile body can be constructed of cast PMI, forged steel, steel alloys, or steel tubing. Various components can be contained within the projectile body cavity, depending on the nature of the round. High explosive rounds used at Range 107 contained either Composition B (Comp B) or TNT. WP rounds contained white phosphorous and a burster charge of either tetryl or RDX (hexahydro-1,3,5-trinitro-s-triazine). Illuminant rounds contained the illuminant charge (magnesium, sodium nitrate, and binders) and its associated parachute subassembly.

The fuse configuration of a mortar round depends on the intended use of the round. HE rounds have point-detonating fuses (PD) which function on impact to initiate the fuse booster charge and in turn the high explosive. WP rounds also contain PD-type fuses which detonate a burster charge which ruptures the projectile body and disperses the white phosphorous filler. Illuminating rounds use a timed fuse which activates an expelling charge and ignites the first-fire charge through a length of quickmatch. The expelling charge separates the illuminant and its parachute from the projectile body allowing them to fall free and provide the illumination affect. Energetics associated with the fuses include RDX, HMX, lead azide, and various primers.

Mortar residues observed and/or recovered at Range 107 include UXO, aluminum fin assemblies from HE, WP, and illuminant rounds, illuminant cases, and projectile body fragments. No propellant charges have been observed.

Technical Data Sheets (TM 43-001-28) are provided in Appendix A for mortar rounds that have been identified as having been used at Range 107 and for residue observed during site walks.

4.3 Explosives Testing Case Studies

The MCAGCC has conducted analytical testing at active ranges throughout the base to evaluate levels of munitions-related chemical constituents. Overall, three such studies were conducted and the information was used to provide a quantitative assessment of munitions residues at active and inactive ranges.

In November 1998, ECC collected representative samples of residue from spent shell casings and ordnance fragments from several ranges at MCAGCC (ECC, 1999a). The purpose of this sample collection was to characterize the chemical components in recently exploded ordnance. A total of 31 samples were collected from various ranges at MCAGCC and analyzed for the parameters listed in Table 4-3. Four of the 31 samples collected contained explosives residues above detectable levels for HMX or RDX (Table 4-4).

A second expended ordnance sampling event was conducted by ECC in June 1999. A total of 25 samples were collected from the stock pile at Range 112 and samples were analyzed for the analytes listed in Table 4-4. Nitrobenzene was the only explosive residue detected in the exploded munitions, and it was only detected in one sample at Range 112 (ECC, 1999b).

Table 4-3. Analytical Parameter Requirements

U.S. EPA Test Methods	Test Name
9045	Corrosivity (pH)
9030	Reactivity (Total Sulfides)
1020	Ignitability (Flashpoint)
8330	Explosives (CDHS-TTLC)
8330	Explosives (CDHS-STLC)
8330	Explosives (TCLP)
8331	Tetrazene (CDHS-TTLC)
8331	Tetrazene (CDHS-STLC)
8331	Tetrazene (TCLP)
CADHS	96 hr Acute Toxicity Bioassay

Source: ECC, 1999a.

Table 4-4. Summary Results of Explosive Testing Case Studies Conducted at MCAGCC

Chemical	Exploded Ordnance (ECC 1999a) Max Conc. 1998 Event [(a)] (mg/kg) (Frequency of Detection)	Range 112 Residue (ECC, 1999b) Max Conc. 1999 Event [(a)] (mg/kg) (Frequency of Detection)	Rainbow Canyon Range (U.S. NEODTD, 1998) Event [(b)] (mg/kg) (Frequency of Detection)	Region 9 PRG (Industrial) (mg/kg)
TNT	ND (0 of 31)	ND (0 of 25)	<0.25 (0 of 5)	57
RDX	87 (2 of 31)	ND (0 of 25)	<0.25 (0 of 5)	16
HMX	15 (2 of 31)	ND (0 of 25)	<0.25 (0 of 5)	31,000
1,3,5-TNB	ND (0 of 31)	ND (0 of 25)	NA	18,000
1,3-DNB	ND (0 of 31)	ND (0 of 25)	NA	62
Nitrobenzene	ND (0 of 31)	0.25 (1 of 25)	NA	100
Tetryl	ND (0 of 31)	ND (0 of 25)	NA	N/A
2,4-DNT	ND (0 of 31)	ND (0 of 25)	NA	1,200
2,6-DNT	ND (0 of 31)	ND (0 of 25)	NA	620
2-Am-DNT	ND (0 of 31)	ND (0 of 25)	NA	N/A
4-Am-DNT	ND (0 of 31)	ND (0 of 25)	NA	N/A
2-Nitrotoluene	ND (0 of 31)	ND (0 of 25)	NA	1,000
3-Nitrotoluene	ND (0 of 31)	ND (0 of 25)	NA	1,000
4-Nitrotoluene	ND (0 of 31)	ND (0 of 25)	NA	1,000
Tetrazene	ND (0 of 31)	ND (0 of 25)	NA	N/A
Nitroglycerin	NA	NA	<0.5 (1 of 5)	120

(a) Results based on Method 8330 TTCL.
(b) Results based on Method 8321.
NA = not analyzed.
ND = not detected.
N/A = not available.
Note: Region 9 PRGs are provided for information only.

During a separate study conducted in 1995, MCAGCC sampled a long-term, high-use, and active range to determine the presence and concentration of munitions-related chemical constituents. The site selected was Rainbow Canyon Range located in the western region of the Base. Rainbow Canyon Range has sustained heavy use from a wide variety of ordinance over several years. Range activities were

halted a week prior to sample collection activities. Discrete samples were collected within a 20-ft by 20-ft grid and sampled at 10 randomly selected locations. Sample results tables for the 1995 sampling event of Rainbow Canyon Range are listed in Table 4-4 (U.S. Naval Explosives Ordnance Disposal Technology Division [U.S. NEODTD], 1998).

4.4 Current and Anticipated Land Use

The CMA and former Ranges 106 and 107 are within MCAGCC and will remain under the control of the U.S. Marine Corps for the foreseeable future.

ESQD arcs, associated with the CMA, have been developed to protect humans from the possible sabotage or accidental detonation of explosives or ammunition (Figure 4-3). ESQD arcs prohibit the placement of inhabited buildings and restrict the movement of public traffic within unsafe distances from ordnance storage facilities.

Future access to former Ranges 106 and 107 is anticipated to be restricted by two levels. Former range land that is directly impacted by CMA expansion activities (paved roads, hard stand, and magazines) are fenced and electronically monitored to prohibit unauthorized civilian or military personnel from gaining access to the facility. Much of the remaining former ranges will fall within the ESQD arcs. Placards indicate the land is a former range and that access is restricted. The proximity of unfenced portions of former Ranges 106 and 107 to the CMA indicates that any intrusion into these areas by unauthorized civilians or military personnel would be investigated by CMA security patrols. The CMA fenceline will be electronically monitored and patrolled by security personnel, and will remain inaccessible to unauthorized personnel.

4.5 Potential Pathways and Receptors

Potential pathways, including soil, groundwater, surface water, and air, were evaluated for human and ecological receptors at former Range 106 and 107. Figure 4-4 is a diagram depicting general conditions (i.e., site features, aquifer depth, future land use, fate and transport mechanisms) impacting potential pathways and receptors.

4.5.1 Groundwater. Due to the relatively low average annual precipitation (approximately 4 inches) and anticipated depth to groundwater (> 400 ft), a groundwater pathway was not considered viable.

4.5.2 Surface Water. Transport of munitions and related constituents via stormwater runoff was estimated to be minimal based on the relatively flat terrain of the site together with minimal precipitation. A visual survey indicated that craters on Ranges 106 and 107 created over 20 years ago by exploding munitions have not been washed out due to storm runoff.

4.5.3 Soil. Although site access is restricted, UXO on former Ranges 106 and 107 pose an explosion hazard for authorized personnel that would be involved in CMA construction activities. Soil penetration depths of up to 3.0 ft (81 mm HE M374) could be expected for UXO based upon a model developed by the Waterways Experiment Station and proofed at Ft. Ord (ECC, 2003).

Explosive residues are not expected to be present in soil at former Ranges 106 and 107. This is based on the detection of only low-levels of explosive constituents during studies conducted at MCAGCC (see Section 4.3), coupled with high temperature and sunlight present at the MCAGCC, which is expected to thermally and photo-chemically degrade explosive residues (Spanggord et al., 1980; Larson et al., 2000).

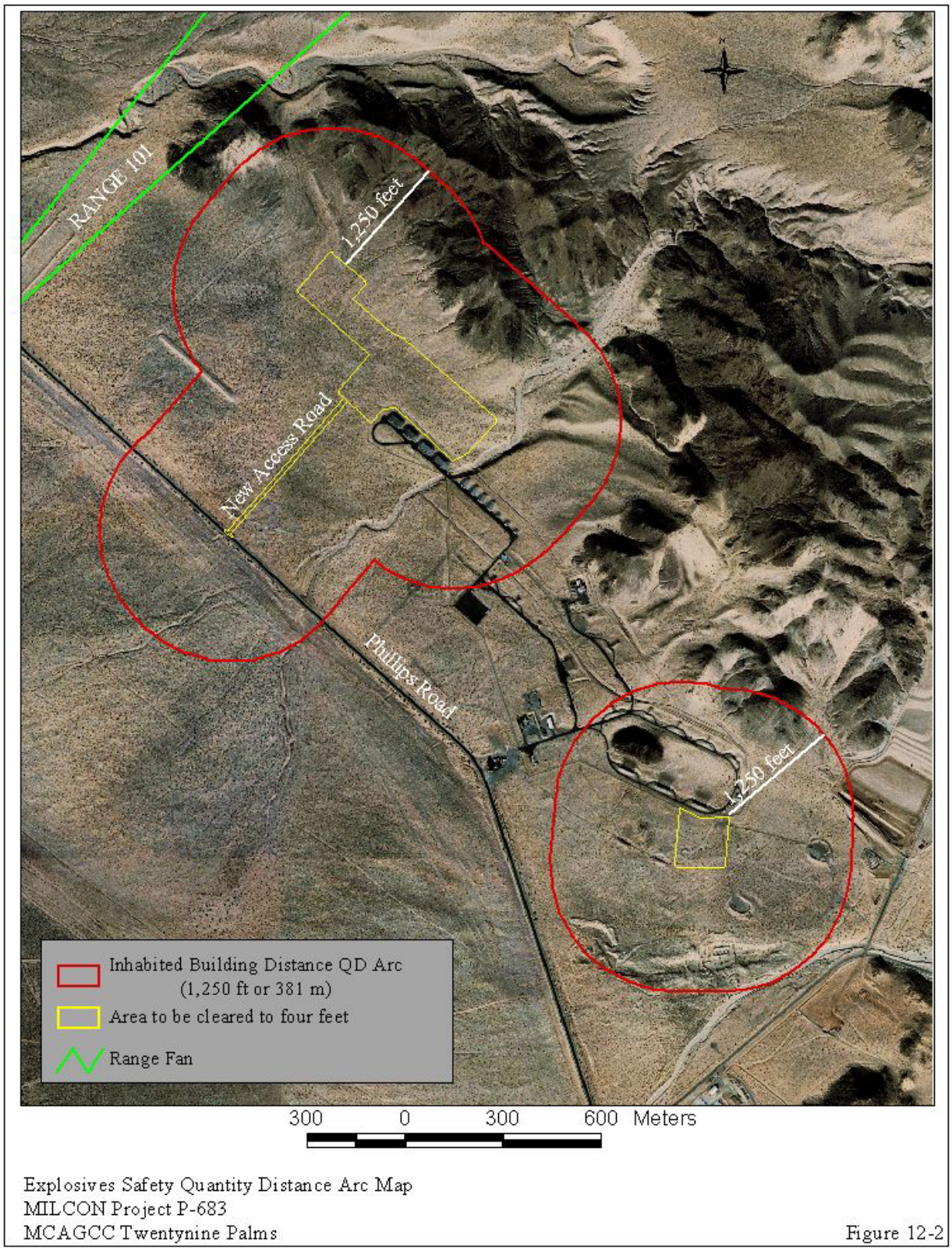

Figure 4-3. Explosives Safety Quantity Distant Arcs and Construction Areas (ECC, 2003)

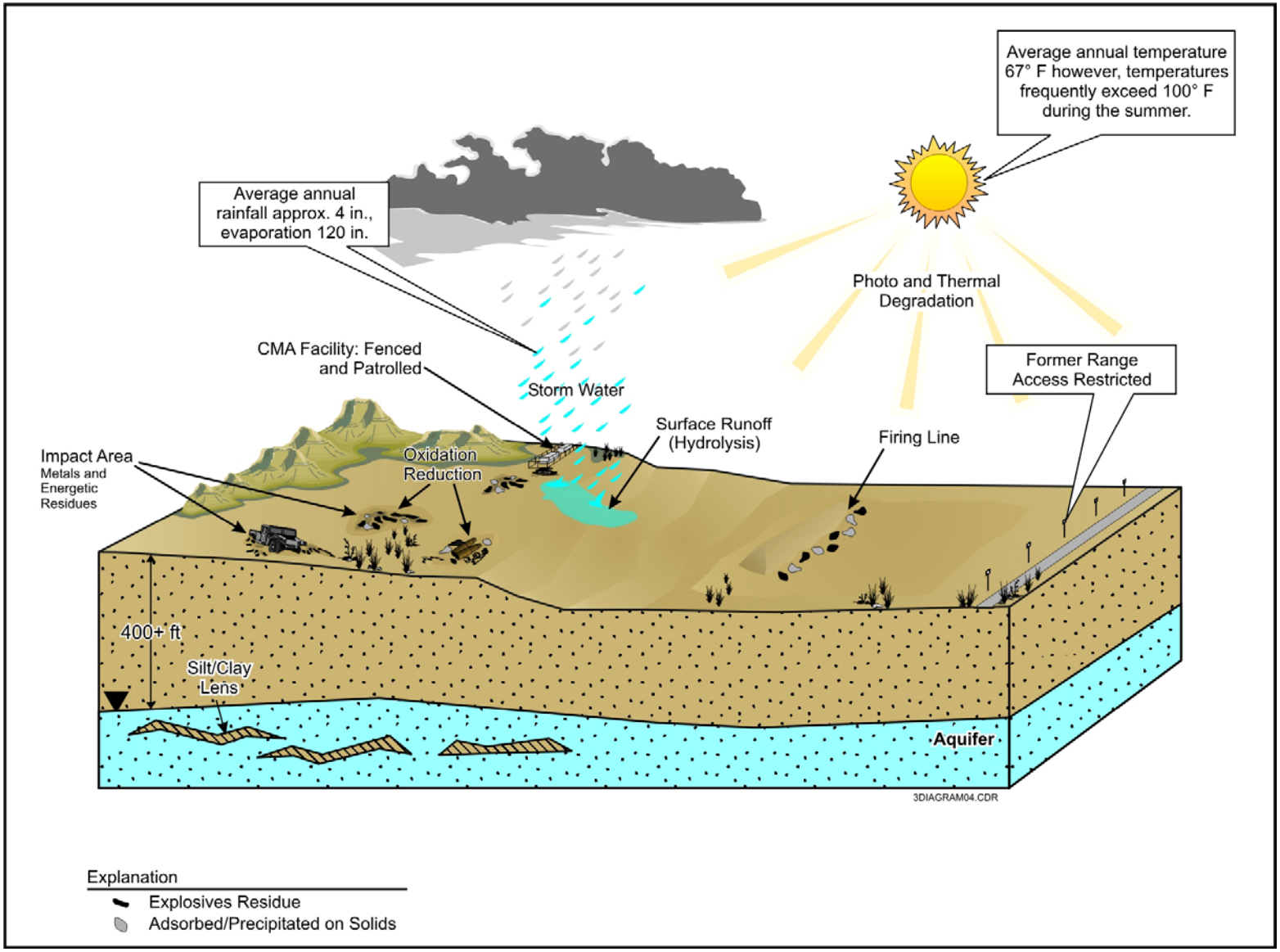

Figure 4-4. Conceptual Diagram of Fate and Transport of Munitions-Related Constituent

Lead particles and bullet fragments found within the ranges may contain particulate lead in excess of the base-wide mean background concentration of 25 mg/kg (Battelle, 1998). However, future land use will limit human access to the former ranges. Additionally, a cleanup level of 5,400 mg/kg was calculated using the Blood Lead Spreadsheet Version 6 (Leadspread) developed by the California Department of Toxic Substances Control (DTSC) as part of the activities at the MCAGCC Small-Arms Range (Battelle, 2001). This cleanup level was based on an industrial worker exposure scenario (8 hours/day, 5 days/week), and would therefore be conservative given the future land use at the CMA.

4.5.4 Air. The air pathway is not expected to be significant for transport of munitions and related constituents. Arid climatic conditions do not promote the corrosion (oxidation and reduction) of UXO or dissolution of energetic residues (Phelan et al., 2001). Visual surveys provide supporting information: mortar fragments, small arms casing, and bullets that display minimal corrosion. Wind transport of particulate lead is a possible transport mechanism and was included in the Leadspread cleanup level developed for the MCAGCC Small-Arms Range.

Section 5.0: MUNITIONS FOCUSED CONCEPTUAL SITE MODEL

A conceptual site model (CSM) was developed using guidance documents issued by the U.S. EPA for hazardous waste sites and the USACE for OE sites. Guidance documents included the U.S. EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA/540/G-89/004) and the latest draft version of the USACE's *Development of Integrated Conceptual Site Models for Environmental and Ordnance and Explosives (OE) Sites.*

The CSM describes the site and its environmental setting based on existing knowledge. The CSM presents (1) UXO and munitions related constituents known or suspected to be at the site; (2) current and future reasonably anticipated proposed land use; (3) actual, potentially complete, or incomplete exposure pathways; and, (4) the potential human and ecological receptors. It describes sources and receptors, and the interactions that link them. The CSM is the basis for the risk evaluation.

The CSM is presented in a series of information profiles about the site. The information profiles are included in Table 5-1.

Table 5-1. Conceptual Site Model Information Profiles

Profile Type	Information Needs	Preliminary Information
Range Profile	Range Structures	No range-related structures (towers, building, etc.) remain in the ranges. Components of vehicles used as targets, remain. Compacted soils associated with abandoned firing lines also are present.
	Range Boundaries	The ranges are bordered on the west by Phillips Road, on the south by the existing CMA, and on the north and east by the Bullion mountains.
	Range Security	A security check is needed to enter the Base. The ranges are subjected to restricted access and the CMA facilities are fenced, electronically monitored, and patrolled.
Munitions/ Release Profile	Munitions Types	The types of munitions used at firing Ranges 106 and 107 are listed in Table 4-1. The most commonly used munitions are: • 60-mm mortars • 81-mm mortars • Small arms munitions 5.56 mm ball 7.62 mm ball 0.30 caliber Match
	Maximum Probability Penetration Depth	0.8 meters (3 ft) based upon the maximum potential penetration depth of 81-mm mortar round (M370 and M374).
	UXO Density	Site walks by EOD personnel identified UXO at Ranges 106 and 107. Density of UXO was not calculated.
	Materials Potentially Presenting an Explosives Hazard	UXO may pose an explosives hazard at former Ranges 106 and 107. Table 4-2 contains the UXO identified during site walks.
	Munitions Residue	During site walks spent munitions casings, fixed target residue, and other munitions residue were identified.
	Associated Munitions Constituents	Sampling data are not available for former Ranges 106 and 107. Sampling results obtained from other ranges at MCAGCC indicate the presence of low level munitions constituents. Thermal and photo-chemical degradation expected.
	Migration Routes/Mechanisms	Erosion – Not Anticipated Surface Water Runoff – Not Anticipated Frost Heave – Not Anticipated Human Contact – Not Anticipated (Current and future use will restrict access)

Table 5-1. Conceptual Site Model Information Profiles (continued)

Profile Type	Information Needs	Preliminary Information
Physical Profile	Climate	Arid upland desert climate. Average temperature is 67°F. In the summer, temperatures frequently exceed 100°F and may reach 120°F. Winter temperatures can drop to 15°F. Annual precipitation is approximately 4 inches.
	Topography	The topography of the entire range is gentle sloping of a southwest-treading alluvial fan. The fan extends from the Bullion Mountains to the northeast to the edge of Mesquite Lake to the south. Two arroyos are present at the site.
	Geology	Portion of a tectonic basin located within the southeast portion of the Mojave Desert geomorphic province. Characterized by a series of normal and strike-slip faults.
	Soil	Unconsolidated deposits of eolian sand, alluvial sand and gravel, lacustrine silts, clay, and evaporates.
	Hydrogeology	Primary water table is identified as the Mesquite Lake Subbasin. Water quality is poor due to high concentrations of fluoride and total dissolved solids. In the vicinity of the CMA, depth to groundwater is estimated to be greater than 400 ft bgs. Water not used due to poor quality.
	Hydrology	The area drains directly towards Mesquite Lake.
	Vegetation	Vegetation types include creosote brush scrub, creosote brush/galleta grass scrub, and dune creosote brush scrub. Undeveloped portion is covered with sparse vegetation.
Land Use and Exposure Profile	Current Land Use	The former range areas are undeveloped.
	Potential Future Land Use	Portion to be used for CMA expansion. Other portions within the EQSD arcs.
	Current Human Receptors	Marine personnel and authorized visitors to MCAGCC.
	Zoning/Land Use Restrictions	No known land use restrictions apply.
	Current Activities (frequency/nature of activity)	Currently, the area is not actively used.
	Potential Future Land Use Related Activities	A portion of the land will be used for CMA expansion. Remaining portions will be left undeveloped with restricted access.
	Beneficial Resources	None
	Demographics/Zoning	Population of Twentynine Palms is 14,700; MCAGCC accommodates approximately 10,000 marines and support staff at any given time.
Ecological Profile	Habitat Type	High desert creosote scrub and bare soils.
	Ecological Receptors	Federal Endangered Species – None Federal Threatened Species – None State Endangered Species – None State Threatened Species – None Other Ecological Receptors – None

Section 6.0: SUMMARY AND RECOMMENDATIONS

UXO on former Ranges 106 and 107 may pose an immediate threat (i.e., an explosion hazard) to human health and safety for authorized personnel that would be involved in CMA construction. Therefore, it is recommended that the MCAGCC conduct a time-critical removal action prior to initiating CMA construction activities.

A final Explosives Safety Submission (ESS) has been prepared for the Navy (ECC, 2003). This document identifies proposed activities for mitigating UXO hazards associated with using land on former Ranges 106 and 107 for the CMA expansion. The mitigation activities include surface/subsurface investigations in the CMA construction footprint and new access road to a depth of 4 ft, which is 1 ft deeper than the maximum penetration depth. The proposed quantity-distance (Q-D) for subsurface investigations and removal of UXO at former Ranges 106 and 107 are shown in Figure 4-3. It is recommended that the ESS serve as the action memorandum for the time-critical removal action.

No action is recommended for the areas of the Former Ranges 106 and 107 that are located outside the construction area. No action is supported as follows:

- Existing institutional controls, including access restrictions, compliance with ESQD regulations, and Marine Corps patrols prevent access.

- Explosive residues are not expected to be present based on the detection of only low-levels of explosive constituents during studies conducted at MCAGCC, coupled with thermal and photo-chemical degradation over the past 20 years.

Section 7.0: REFERENCES

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APPENDIX A

Ordnance Technical Data Sheets